

What is claimed is:

1. An ablation catheter comprising:

an elongated catheter body extending between a catheter body proximal end and a catheter body distal end, the elongated catheter body including elongated electrical conductors extending between the catheter body proximal end and the catheter body distal end, a fluid port positioned in proximity to the catheter body proximal end and a fluid delivery lumen extending between the port and the catheter body distal end; and

a virtual electrode assembly terminating the catheter body distal end and including an inner electrode electrically coupled to the elongated conductors, a non-conductive outer cap fixed over the electrode and a fluid chamber formed between the inner electrode and the outer cap;

wherein the outer cap includes a cap inner surface, a cap outer surface and a plurality of pores extending between the cap inner surface and the cap outer surface;

the inner electrode includes an interior fluid trunk in fluid communication with the fluid delivery lumen of the catheter body, an exterior surface, one or more fluid distribution branches extending from the fluid trunk to the exterior surface, and one or more spacers protruding from the exterior surface and contacting the cap inner surface to maintain the fluid chamber between the inner electrode and the outer cap; and

when the inner electrode is energized, via the elongated conductor, and a conductive fluid is delivered through the one or more fluid distribution branches from the fluid trunk, supplied by the fluid delivery lumen of the catheter, the conductive fluid fills the fluid chamber and flows out from the chamber through the plurality of pores of the cap establishing ionic transport of ablation energy from the inner electrode to a target site in close proximity to the cap.

2. The ablation catheter of claim 1, further comprising a connector ring facilitating coupling of the virtual electrode to the catheter body distal end.

3. The ablation catheter of claim 1, wherein the outer cap further includes a dome-shaped distal end region.
4. The ablation catheter of claim 1, wherein the outer cap further includes one or more detents engaging the one or more spacers of the inner electrode.
5. The ablation catheter of claim 2, wherein the outer cap further includes a detent engaging the connector ring.
6. The ablation catheter of claim 1, wherein the outer cap is formed of a material comprising a rigid plastic.
7. The ablation catheter of claim 1, wherein the outer cap is formed of a material comprising a ceramic.
8. The ablation catheter of claim 1, wherein the outer cap is formed of a material comprising a fluoro-polymer.
9. The ablation catheter of claim 1, wherein the outer cap is formed of a material comprising an epoxy resin.
10. The ablation catheter of claim 1, wherein the plurality of pores are arrayed longitudinally along a length of the outer cap and circumferentially 360 degrees around the outer cap.
11. The ablation catheter of claim 2, wherein the plurality of pores are arrayed longitudinally along a length of the outer cap and circumferentially 360 degrees around the outer cap extending over the dome-shaped distal end region.

11

12. The ablation catheter of claim 1, wherein a maximum diameter of each of the plurality of pores is sized to prevent ingress of blood cells into the fluid chamber from the cap outer surface.

13. The ablation catheter of claim 1, wherein a maximum diameter of each of the plurality of pores is between approximately 0.0005 inch and 0.005 inch.

14. The ablation catheter of claim 1, wherein the plurality of pores is formed by a process selected from the group consisting of laser drilling, chemical etching and sintering.

15. The ablation catheter of claim 1, wherein a maximum distance between the exterior surface of the electrode and the cap inner surface is between approximately 0.003 inch and approximately 0.005 inch.

16. The ablation catheter of claim 1, wherein the exterior surface of the electrode includes extensions increasing a surface area of the exterior surface.

17. The ablation catheter of claim 16, wherein the extensions form a spiral coil.

18. The ablation catheter of claim 1, wherein the one or more spacers extend circumferentially about a proximal end of the electrode.

19. The ablation catheter of claim 1, wherein the one or more spacers extend distally from a distal end of the electrode.

20. The ablation catheter of claim 1, wherein a one of the one or more fluid distribution branches passes through a one of the one or more spacers.

21. The ablation catheter of claim 20, wherein the one of the one or more spacers extends distally from a distal end of the electrode.
22. The ablation catheter of claim 21, wherein the cap further includes a hole extending from the cap inner surface to the cap outer surface and generally aligned and in fluid communication with the one of the one or more fluid distribution branches.
23. The ablation catheter of claim 1, wherein a diameter of the fluid trunk of the electrode is between approximately 0.005 inch and approximately 0.030 inch.
24. The ablation catheter of claim 1, wherein a diameter of each of the one or more fluid distribution branches is between approximately 0.005 inch and approximately 0.030 inch.
25. A virtual ablation electrode assembly, comprising:
- a non-conductive outer cap including a cap inner surface, a cap outer surface and a plurality of pores extending between the cap inner surface and the cap outer surface;
 - an inner electrode including an interior fluid trunk, an exterior surface, one or more fluid distribution branches extending from the fluid trunk to the exterior surface, and one or more spacers protruding from the exterior surface and contacting the cap inner surface; and
 - a fluid chamber formed between the inner electrode and the outer cap and maintained by the one more spacers;
- wherein, when the electrode is energized and when fluid is delivered through the one or more fluid distribution branches from the trunk, the conductive fluid fills the fluid chamber and flows out from the chamber through the plurality of pores of the cap establishing ionic transport of

ablation energy from the inner electrode to a target site in close proximity to the cap.

26. The virtual ablation electrode assembly of claim 25, wherein the outer cap further includes a dome-shaped distal end region.

27. The virtual ablation electrode assembly of claim 25, wherein the outer cap further includes one or more detents engaging the one or more spacers of the inner electrode.

28. The virtual ablation electrode assembly of claim 25, wherein the outer cap is formed of a material comprising a rigid plastic.

29. The virtual ablation electrode assembly of claim 25, wherein the outer cap is formed of a material comprising a ceramic.

30. The virtual ablation electrode assembly of claim 25, wherein the outer cap is formed of a material comprising a fluoro-polymer.

31. The virtual ablation electrode assembly of claim 25, wherein the outer cap is formed of a material comprising an epoxy resin.

32. The virtual ablation electrode assembly of claim 25, wherein the plurality of pores are arrayed longitudinally along a length of the outer cap and circumferentially 360 degrees around the outer cap.

33. The virtual ablation electrode assembly of claim 26, wherein the plurality of pores are arrayed longitudinally along a length of the outer cap and circumferentially 360 degrees around the outer cap extending over the dome-shaped distal end region.

34. The virtual ablation electrode assembly of claim 25, wherein a maximum diameter of each of the plurality of pores is sized to prevent ingress of blood cells into the fluid chamber from the cap outer surface.
35. The ablation catheter of claim 25, wherein a maximum diameter of each of the plurality of pores is between approximately 0.0005 inch and 0.005 inch.
36. The virtual ablation electrode assembly of claim 25, wherein the plurality of pores is formed by a process selected from the group consisting of laser drilling, chemical etching and sintering.
37. The virtual ablation electrode assembly of claim 25, wherein a maximum distance between the exterior surface of the electrode and the cap inner surface is between approximately 0.003 inch and approximately 0.005 inch.
38. The virtual ablation electrode assembly of claim 25, wherein the exterior surface of the electrode includes extensions increasing a surface area of the exterior surface.
39. The virtual ablation electrode assembly of claim 38, wherein the extensions form a spiral coil.
40. The virtual ablation electrode assembly of claim 25, wherein the one or more spacers extend circumferentially about a proximal end of the electrode.
41. The virtual ablation electrode assembly of claim 25, wherein the one or more spacers extend distally from a distal end of the electrode.

42. The virtual ablation electrode assembly of claim 25, wherein a one of the one or more fluid distribution branches passes through a one of the one or more spacers.

43. The virtual ablation electrode assembly of claim 42, wherein the one of the one or more spacers extends distally from a distal end of the electrode.

44. The virtual ablation electrode assembly of claim 43, wherein the cap further includes a hole extending from the cap inner surface to the cap outer surface and generally aligned and in fluid communication with the one of the one or more fluid distribution branches.

45. The virtual ablation electrode assembly of claim 25, wherein a diameter of the fluid trunk of the electrode is between approximately 0.005 inch and approximately 0.030 inch.

46. The virtual ablation electrode assembly of claim 25, wherein a diameter of each of the one or more fluid distribution branches is between approximately 0.005 inch and approximately 0.030 inch.

47. A method delivering ablation energy to a target site, comprising:
causing conductive fluid to flow through one or more fluid distribution branches of an electrode, which terminates a distal end of a catheter, into a fluid chamber, which is formed between an exterior surface of the electrode and an inner surface of a non-conductive outer cap fixed over the electrode, and out through a plurality of pores formed in a wall of the outer cap;
energizing the electrode to deliver ablation energy via the conductive fluid flowing out through the plurality of pores; and
pushing or dragging the distal end of the catheter along a target ablation site.

48. A method for assembling a virtual ablation electrode catheter, comprising:

fitting a connector ring into a distal end of a catheter body;

coupling an electrode to the connector ring; and

coupling a non-conductive cap to the electrode by fitting the cap over one or more spacers extending from an exterior surface of the electrode.

49. The method of claim 48, further comprising coupling the non-conductive cap to the connector ring by engaging the connector ring with a detent formed in the cap.

50. The method of claim 48, wherein coupling the cap to the electrode includes engaging the one or more spacers with one or more detents formed in the cap.

51. The method of claim 48, wherein coupling the cap to the electrode includes a friction fit between an inner surface of the cap and the one or more spacers.